LCA at the Department of Energy (DOE), National Energy Technology Laboratory (NETL)

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MISSION
Advancing energy options to fuel our economy, strengthen our security, and improve our environment

National Energy Technology Laboratory

Pittsburgh, PA
Morgantown, WV
Sugar Land, TX
Fairbanks, AK
Albany, OR

Oregon
Pennsylvania
West Virginia
Overview of Energy Life Cycle Analysis at NETL
(The Agenda)

- Purpose of LCA at NETL
- NETL Modeling Approach
- Recently Published LCA Work
- How to Access NETL’s LCA Work
Purpose of Life Cycle Analysis at NETL

1. Produce Energy System LCAs
   - Inform and defend the Technology Programs
   - Baseline different energy system technologies
   - Understand technology strengths and weaknesses when viewed from a life cycle perspective
   - Identify opportunities for R&D innovation (through depth and transparency of analysis)

2. Improve LCA methods
   - Expand inventory
   - Characterize uncertainty and variability
   - Build flexible and dynamic models
   - Keep data collection and modeling current with state-of-the-art LCA

3. Enhance interpretation and comparability of inventory results without losing depth and transparency
   - Stochastic simulation of life cycle inventory
   - Tools to explore uncertainty and variability
NETL Life Cycle Analysis Approach

- Compilation and evaluation of the inputs, outputs, and the potential environmental impacts of a product or service throughout its life cycle, from raw material acquisition to the final disposal

- The ability to compare different technologies depends on the functional unit (denominator); for power LCA studies:
  - 1 MWh of electricity delivered to the end user
NETL Life Cycle Study Metrics

- **Greenhouse Gases**
  - CO₂, CH₄, N₂O, SF₆

- **Criteria Air Pollutants**
  - NOₓ, SOₓ, CO, PM10, Pb

- **Air Emissions Species of Interest**
  - Hg, NH₃, radionuclides

- **Solid Waste**

- **Raw Materials**
  - Energy Return on Investment

- **Water Use**
  - Withdrawn water, consumption, water returned to source
  - Water Quality

- **Land Use**
  - Acres transformed, greenhouse gases

- **Life Cycle Cost**
  - Cost of Electricity (COE), Total Overnight Cost (TOC)

**Converted to Global Warming Potential using IPCC 2007 100-year CO₂ equivalents**

- CO₂ = 1
- CH₄ = 25
- N₂O = 298
- SF₆ = 22,800
Research, Model, Document…Repeat

- Life Cycle Inventory (LCI) data is developed from a wide range of sources from primary to secondary data
  - The type of data used depends on the “use” of the data within the analysis being conducted
- All data and calculations are documented in NETL’s standardized unit process spreadsheet and documentation formats for quality assurance review
- Unit processes are imported into the GaBi Life Cycle Assessment Software (PE International)
- Unit processes are assembled (modeled) to represent the scope of the LCA of interest
- Results are evaluated, significant data contributions are improved, and finally study results are documented
Uncertainty Matters when Comparing Alternatives

• Data Uncertainty (or Variability) – does the data accurately represent what was modeled, is there variability in the key parameters

• Model Uncertainty – introduced by choices the LCA Practitioner makes; e.g., the choice of allocation procedure, impact assessment method, etc.

• Scenario Uncertainty – applied when multiple design options or implementation strategies are possible
Example of Model Uncertainty (allocation)

Scenario “X”

GHG Emissions (g CO₂e/MJ, IPCC 2007, 100-yr GWP)

- **Baseline values**
- **Simulation maximum**
- **95th percentile; 95% of simulated results are below this value**
- **75th percentile**
- **Mean, or average**
- **Median, or 50th percentile**
- **25th percentile**
- **5th percentile**
- **Minimum**

**Energy** | **System Exp.** | **Combined**
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84.0 | | 95.2
106.3 | |
Recently Published LCA Work
2012 Technology Assessment Reports

1. Natural Gas (NGCC and GTSC)
2. Pulverized Coal and Biomass Cofiring
3. Nuclear (existing, upgrade, & new)
4. Wind (with and without back-up)
5. Hydropower (existing, upgrade, & new)
6. Solar Thermal
7. Geothermal (flash steam)

Reports & Presentations can be accessed at:

www.netl.doe.gov/energy-analyses
Life Cycle Analysis at NETL
- Methodology includes the critical analysis of scope, assumptions, level of detail, data quality, interpretation of results, etc.
- Purpose is to perform and publish a transparent LCA
- NETL LCA studies are ISO 14040 compliant

Unit Process Documentation
- Two primary documents – the process documentation file (DF) and the data summary sheet (DS)
- DS contains all of the parameters, inputs, and outputs for a given system as well as background data, calculations and quality scores
- DF contains major assumptions and data sources that are the basis for each of the unit processes
- All unit processes go through a full QA check prior to addition to the library

Published LCA Product Library
- Role of Alternative Energy Sources Technology Assessments (2012):
  - Coal/Biomass Co-firing
  - Geothermal
  - Hydropower
  - Natural Gas
  - Nuclear
  - Solar Thermal
  - Wind
- NETL Upstream Dashboard Tool (2012)
- Life Cycle Greenhouse Gas Inventory of Natural Gas Extraction, Delivery, and Electricity Production (2011)

LCA reports and products can be accessed at: www.netl.doe.gov/energy-analyses

NETL unit processes can be accessed at: www.netl.doe.gov/LCA
Power Life Cycle Analysis Tool (Power LCAT)

- Interactive comparison tool (PowerSim) which gives users access to key financial and environmental results and parameters from detailed power LCAs.
- Ongoing partnership between NETL and Sandia National Laboratory.

Included Technologies:
- IGCC
- IGCC/ccs
- EXPC
- EXPC/ccs
- EXPC/ccs + RP
- SCPC
- SCPC/ccs
- NGCC
- NGCC/ccs
- Onshore Wind
- Gen III+ Nuclear

Sliders allow user to control assumptions and see results update in real time.

Power LCAT can be accessed at: www.netl.doe.gov/energy-analyses

Search Term “LCAT”
The Upstream Dashboard Tool

Upstream Dashboard Tool can be accessed at:

www.netl.doe.gov/energy-analyses

Search Term “Dashboard”
How to Access NETL’s LCA Work

• NETL Energy Analyses Website, Search for “LCA”
  – www.netl.doe.gov/energy-analyses

• Email the NETL LCA Team with Questions
  – LCA@NETL.DOE.GOV

• Collaborate with NETL on Energy Related LCA Studies
  – Contact Tim Skone, 412-386-4495 or skonet@netl.doe.gov
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